

ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 9

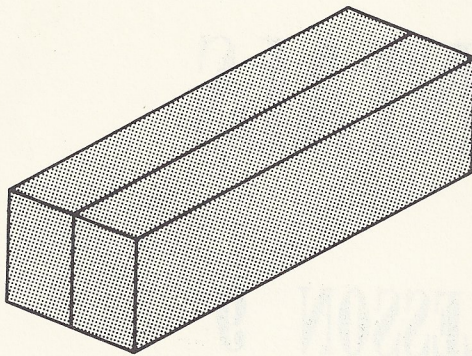
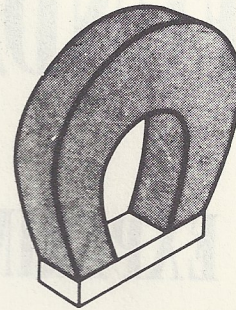
POWER MEASUREMENT



RCA INSTITUTES, INC.

**A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL**

350 West 4th Street, New York 14, N. Y.

*two bar magnets**horseshoe magnet with keeper*

All the parts in Kit 5 are listed below. Check the parts you receive against this list. Make sure you have the correct quantity of every item. If a part is either missing or defective upon arrival, request a replacement from Department R, Home Study School, RCA Institutes, Inc., 350 West 4th Street, New York 14, N.Y. *Your request must include your name and student number, the complete name and description of the part copied from the Item column below, the Quantity missing or defective, and the reason you are asking for a new part.*

KIT 5**BILL OF MATERIALS**

Quantity	Item
1	Container of iron filings
2	Alnico bar magnets
1	Horseshoe magnet and keeper
1	Compass
$\frac{1}{4}$ lb	Plain enamel magnet wire
1	40-penny iron nail
1	Resistor, 15 ohms, $\frac{1}{2}$ watt
1	Resistor, 4.7 k-ohms, $\frac{1}{2}$ watt, 10%

Experiment Lesson 9

OBJECT

1. To calculate d-c power by using voltage and current measurements.
2. To determine the effect that a change in load has upon the voltage division of a voltage divider.
3. To set up a voltage-divider circuit that provides voltages that are positive and negative with respect to a reference point (ground).

INFORMATION

In Theory Lesson 11, *D-C Meter Theory*, you will learn that power can be measured directly in watts by using a special kind of meter called a *wattmeter*. However, it is possible to discover how much power a piece of d-c equipment consumes by measuring the voltage that appears across the equipment and the current that flows through it. Then, by using the Ohm's law formula, $P = E \times I$, we can find the power. In the experiments that follow, you will do this.

EXPERIMENT 9-1

To determine the power consumed by a resistor.

Equipment Needed.

The resistor board assembled in Experiment Lesson 1.

Three 1.5-volt dry cells and the alligator clips used in Experiment Lesson 7.

Soldering iron, cloth, and solder.

4. Short lengths of hook-up wire used in Experiment Lesson 7.

Procedure.

Step 1. Solder a short length of hook-up wire to one lead of the 220-ohm resistor on the breadboard.

Step 2. Solder the other end of the same lead to the 100-ohm resistor, as shown in Fig. 9-1.

Step 3. Make sure that the three 1.5-volt cells are connected in series aiding to form a 4.5-volt battery and that there is an alligator clip attached to each terminal.

Step 4. Clip the negative terminal of the battery to the free end of the 100-ohm resistor. Connect the positive terminal to the free end of the 220-ohm resistor, as shown in Fig. 9-1.

Step 5. Set up your multimeter for service on the 5-volt d-c range.

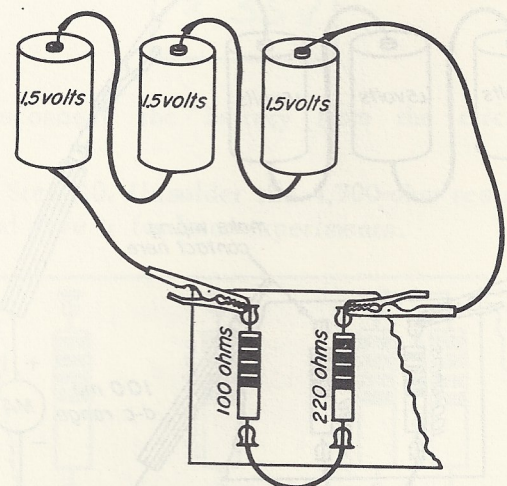


Fig. 9-1

Step 6. Measure and record the voltage across the 100-ohm resistor here:

1.3 v

Step 7. Measure and record the voltage across the 220-ohm resistor here:

3.1 v

Step 8. Measure and record the total voltage across both resistors here:

4.52 v

Step 9. Remove the battery clip from the 220-ohm resistor.

Step 10. Set your multimeter to measure current on the 100-milliampere d-c range.

Step 11. Clip the positive terminal of the battery to the red (+) test lead.

Step 12. With the negative test prod, make a wiping contact with the free end of

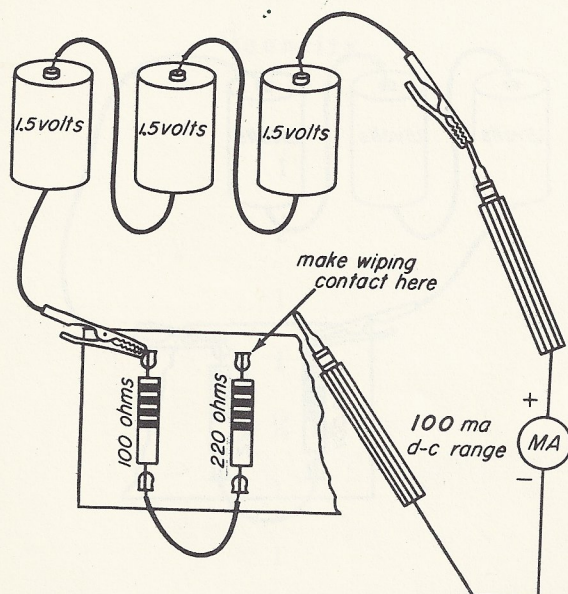


Fig. 9-2

the 220-ohm resistor. At the same time, watch the meter. If the pointer rises too rapidly and too far toward the right, remove the meter from the circuit and check your circuit to see that it agrees with Fig. 9-2.

Step 13. Connect the negative test prod to the free end of the 220-ohm resistor and record the current reading here:

13.5 ma

Step 14. Use the formula for power, $P = E \times I$, to calculate the power consumed by the 100-ohm resistor. Record the value here:

.01755 w

1.3
.0135
65
39
13
01755

Step 15. Calculate the power consumed by the 220-ohm resistor. Record the value here:

.04185

3.1
.0135
155
93
31
04185

Discussion. With the rated values of the 100- and 220-ohm resistors, there should have been a resistance of about 320 ohms. The meter resistance (10 ohms on the 100 MA range) is small compared to 320 ohms and may be neglected here. By using Ohm's law, you can see that the current flowing in the circuit is equal to 4.5 volts divided by 320, which equals about 0.014 amperes (14 ma). Therefore, the value of current that you measured in Step 12 should have been about 14 ma. The voltage across the 100-ohm resistor may then be calculated by using Ohm's law:

$$E = I \times R = 0.014 \times 100 = 1.4 \text{ volts}$$

The voltage across the 220-ohm resistor may be found in the same manner:

$$E = I \times R = 0.014 \times 220 = 3.1 \text{ volts}$$

The voltage reading you got in Step 6 should have been about 1.4 volts, and the reading in Step 7 should have been about 3.1 volts. If the values that you measured differed greatly from these, check the voltage reading that you made at Step 8. If it is less than 4.4 volts, your voltage readings should be slightly off. However, if the voltage is 4.4 or more, make sure that the battery is removed from the circuit and then use your ohmmeter to measure the resistance of the 100-ohm and 220-ohm resistors. If the resistance values are about what they should be, repeat the experiment. Be careful to take very accurate readings. If your current and voltage readings are about what they should be, you will find that the power consumed in the 100-ohm resistor is about 19.6 milliwatts (0.0196 watts), and the power consumed by the 220-ohm resistor is about 43 milliwatts (0.043 watts).

EXPERIMENT 9-2

To determine the effect that a change in load has upon a voltage divider.

Equipment Needed.

Equipment used in Experiment 9-1

The resistors used in Experiment Lesson 2

Procedure.

Step 1. Connect and solder one end of the 10,000-ohm resistor to the 1,000-ohm resistor on the breadboard, as in Fig. 9-3.

Step 2. Clip one terminal of the 4.5-volt battery to the free end of the 1,000-ohm resistor and the other terminal to the free end of the 10,000-ohm resistor.

Step 3. Set up your multimeter for service on the 5 VDC range.

Step 4. Measure the voltage across the 1,000-ohm resistor and record it here:

4v

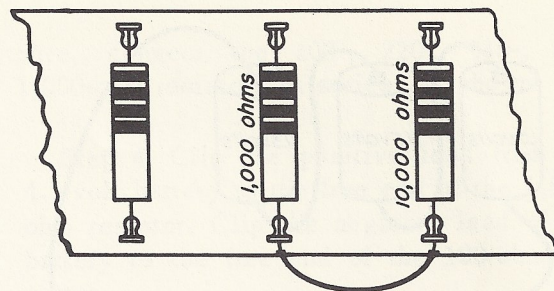


Fig. 9-3

Step 5. Measure the voltage across the 10,000-ohm resistor and record it here.

4.05V

Disconnect the battery from the resistors.

Step 6. Connect and solder the 4,700-ohm resistor that you received in Kit 5 across the 10,000-ohm resistor, as in Fig. 9-4.

Step 7. Connect the battery across this combination of resistors.

Step 8. Measure the voltage across the 1,000-ohm resistor and record it here:

1.5V

Step 9. Measure the voltage across the two parallel resistors and record it here:

3.35V

Disconnect the battery from the circuit.

Step 10. Unsolder the 4,700-ohm resistor and save it for later experiments.

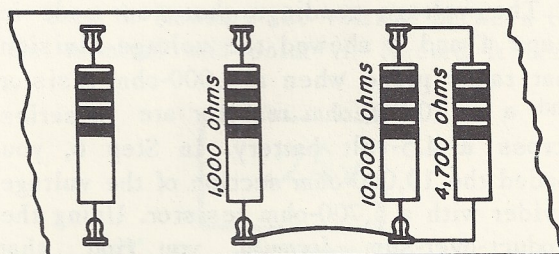


Fig. 9-4

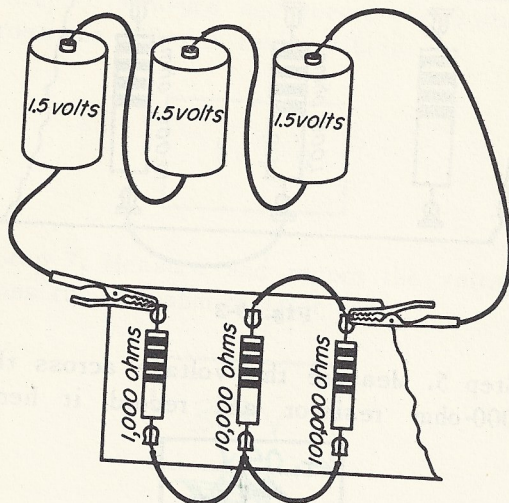


Fig. 9-5

Step 11. Connect and solder the 10,000-ohm and 100,000-ohm resistors of the resistor breadboard in parallel.

Step 12. Connect the battery across the resistor circuit, as shown in Fig. 9-5.

Step 13. Measure the voltage across the 1,000-ohm resistor and record it here:

4v

Step 14. Measure the voltage across the parallel-connected 10,000-ohm and 100,000-ohm resistors and record it here:

4v

Disconnect the battery from the circuit.

Discussion.

The voltage readings that you made in Steps 4 and 5 showed the voltage division that takes place when a 1,000-ohm resistor and a 10,000-ohm resistor are in series across a 4.5-volt battery. In Step 6, you loaded the 10,000-ohm section of the voltage divider with a 4,700-ohm resistor. Using the product-over-sum formula, you find that 4,700 ohms in parallel with 10,000 ohms equal:

$$\begin{array}{rcl} 4,700 \times 10,000 & & 47,000,000 \\ 4,700 + 10,000 & & 14,700 \end{array}$$

$$= 3,200 \text{ ohms approx.}$$

Placing the 4,700 ohms in parallel with the 10,000-ohm resistor made that part of the circuit act like 3,200 ohms. As a result, the voltage distribution changed. Where the readings taken in Steps 4 and 5 were about 0.4 of a volt and 4.1 volts, the voltage now became about 1 volt across the 1,000-ohm resistor and about 3.5 volts across the two parallel resistors.

On the other hand, when the 100,000-ohm resistor was placed as a load across the 10,000-ohm resistor, there was so very little difference in the voltage distribution that you could well ignore it. In other words, the voltage distribution remained just about the same as it was when we had only the 1,000-ohm and the 10,000-ohm resistors in series.

The greater the load (the less the resistance of the load) that we place across any section of a voltage divider, the greater is the change in the distribution of voltage. Therefore, we never can calculate the value of any section of a voltage divider until we first know the value of the load that will be placed across it.

EXPERIMENT 9-3

To set up a voltage-divider circuit that provides voltages that are positive and negative with respect to a reference point (ground).

Equipment Needed.

The equipment used in the previous experiments in this lesson.

One tie terminal used in Experiment Lesson 2.

One screw to mount the tie terminal.

Information. In the following experiments, keep track of the polarity of your test leads

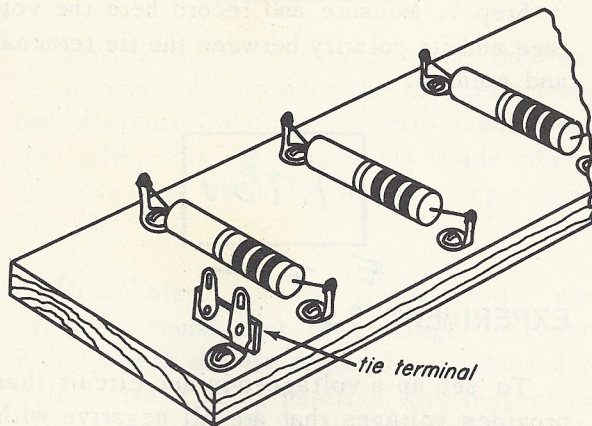
as you check each voltage measurement. Keeping a record of the polarity is very important; unless you do this, your work on these experiments will be wasted and you will not learn what you are supposed to learn from them.

Procedure.

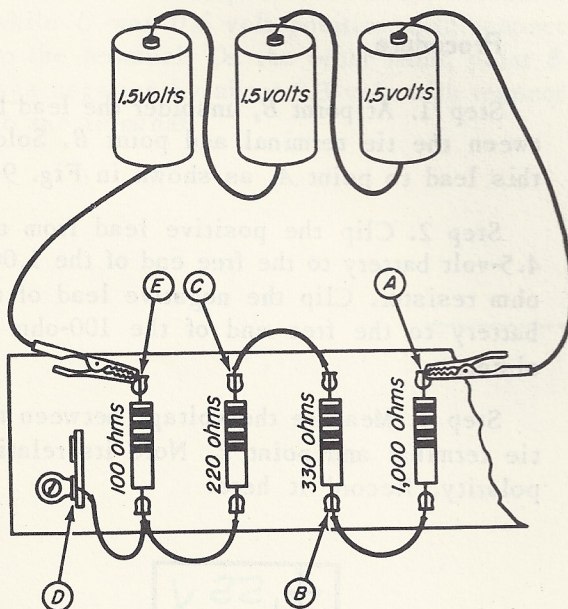
Step 1. Mount the tie terminal on the resistor breadboard, as shown in Fig. 9-6a.

Step 2. Use a short length of hook-up wire to connect the near end of the 100-ohm resistor to the tie terminal, as shown in Fig. 9-6b.

Step 3. Using short lengths of hook-up



(a)



(b)

Fig. 9-6

wire, connect the 100-, 220-, 330-, and 1,000-ohm resistors in series, as shown.

Step 4. Clip the positive lead from the 4.5-volt battery to the free end of the 1,000-ohm resistor. Clip the negative lead of the battery to the free end of the 100-ohm resistor.

Step 5. Using the 5 VDC range of your multimeter, measure the voltage between the tie terminal (point D) and point A. Record it here:

4.25v

A = +

Note, too, the polarity of point A with reference to the tie terminal.

Step 6. Measure the voltage between point B and the tie terminal. Record it here:

1.5v

B = +

Note the polarity as before.

Step 7. Measure the voltage between the tie terminal and point C and record it here:

1.6v

C = +

Note the polarity at point C with respect to the tie terminal.

Step 8. Measure the voltage between the tie terminal and point E. Record it here:

2.5v

E = -

Note the polarity with respect to the tie terminal.

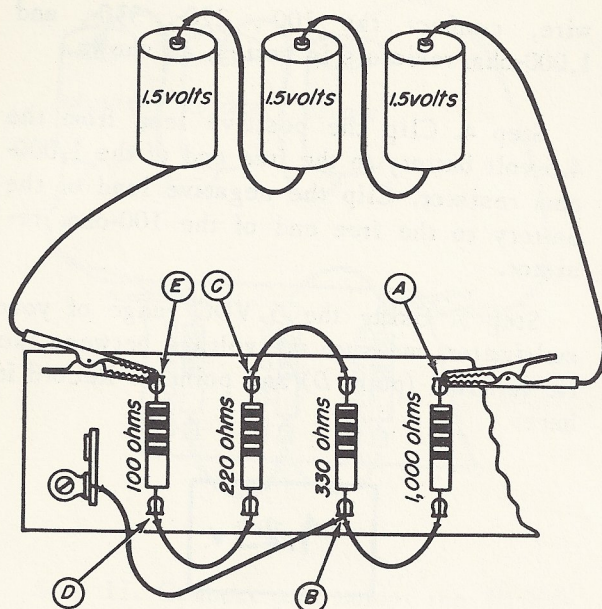


Fig. 9-7

EXPERIMENT 9-4

To set up another voltage divider that provides voltages that are positive and negative with respect to a reference point (ground).

Procedure.

Step 1. At point *D*, unsolder the lead between point *D* and the tie terminal.

Step 2. Solder the free end of this lead to point *B*, as shown in Fig. 9-7.

Step 3. Clip the positive lead from the 4.5-volt battery to the free end of the 1,000-ohm resistor. Clip the negative lead of the battery to the free end of the 100-ohm resistor.

Step 4. Measure the voltage between point *A* and the tie terminal and note its polarity with reference to the tie terminal as before. Record the polarity and voltage here:

2.65

A = +

Step 5. Measure the voltage between point *C* and the tie terminal. Note its polarity

with respect to the tie terminal. Record the polarity and voltage here:

.9v

E = -

Step 6. Measure and record here the voltage and its polarity between the tie terminal and point *D*:

1.5v

D = -

Step 7. Measure and record here the voltage and its polarity between the tie terminal and point *E*:

1.75v

E = -

EXPERIMENT 9-5

To set up a voltage-divider circuit that provides voltages that are all negative with respect to a reference point (ground).

Procedure.

Step 1. At point *B*, unsolder the lead between the tie terminal and point *B*. Solder this lead to point *A*, as shown in Fig. 9-8.

Step 2. Clip the positive lead from the 4.5-volt battery to the free end of the 1,000-ohm resistor. Clip the negative lead of the battery to the free end of the 100-ohm resistor.

Step 3. Measure the voltage between the tie terminal and point *E*. Note its relative polarity. Record it here:

4.55v
neg

Step 4. Measure and record the voltage between the tie terminal and point C. Note its polarity:

3.6 V
~~4.25 V~~
 neg.

Step 5. Measure and record the voltage between the tie terminal and point D. Note its polarity:

4.25 V
 neg.

Step 6. Unclip the leads from the terminal board. Disconnect the dry cells from one another. Unsolder the clip leads from the cells. Put the clip leads aside where you can find them for a later Experiment Lesson.

Discussion. In Experiment 9-3, you probably found that the voltage between point A and the tie terminal was about 4.2 volts, with A being positive with respect to the tie terminal. Point B was about 1.5 volt positive with respect to the tie terminal, while C was 0.6 volt positive with respect to the terminal. On the other hand, point E was negative by about 0.3 volt with respect to the terminal.

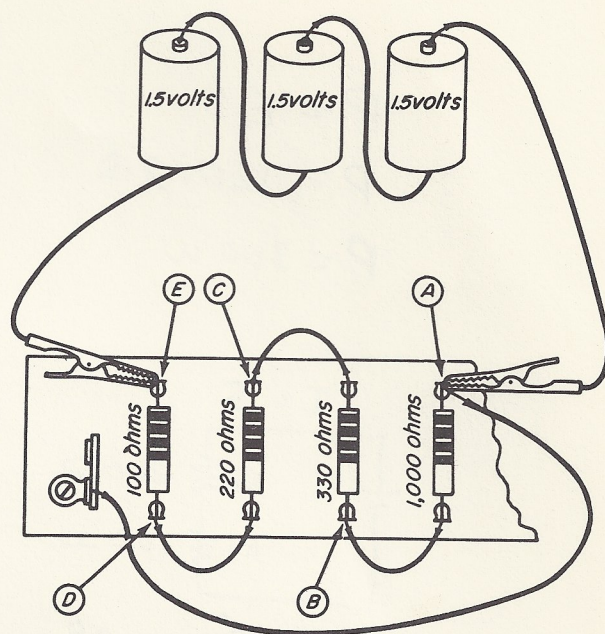


Fig. 9-8

In Experiment 9-4, point A was about 2.7 volts positive with respect to the tie terminal. Point B was 0 volts, point C was about 0.9 volt negative, point D was about 1.5 volts negative, and point E was about 1.8 volts negative with respect to the tie terminal. In Experiment 9-5, all voltages were negative with respect to the tie terminal.

If we consider the tie terminal to be our ground connection, you can see that it is possible to have any number of voltages positive or negative with respect to ground or to any other reference point that we wish to set up.